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SIXTY-EIGHTH

ANNUAL REPORT

OF THE

DIRECTOR

OF

THE ASTRONOMICAL OBSERVATORY

OF

HARVARD COLLEGE

FOR THE YEAR ENDING SEPTEMBER 30, 1913

BY

EDWARD C. PICKERING

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CAMBRIDGE, MASS.
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THE OBSERVATORY

To the President of the University: —

Sir, — The last year has emphasized the plans for the work of the Observatory outlined in previous reports. It has gradually become an institution having a great field of work, in close relations with other similar institutions, which depend upon its occupying its special field. The visit of the Director to Europe last summer has rendered these ties still closer, as few astronomers of eminence were absent from the astronomical gatherings held there. To increase its usefulness, the Observatory has lent about five thousand dollars worth of its equipment to fifteen astronomers who were thus enabled to make good use of it. In a single case only, were the results unsatisfactory. The use of one of the instruments was offered to a person who, after availing himself of the offer for several months, threatened suit unless a salary was paid him for all his observations. It is, therefore, necessary to state that the Observatory will not pay a salary to any one borrowing or using its instruments, books, or photographs, unless some arrangement to the contrary is made in advance.

It does not appear to be generally known that no portion of the funds of the University are used for the support of the Observatory. Our entire income is derived from gifts made to the President and Fellows of Harvard College specifically for the Observatory. Accordingly, the large sums given to the College have not in any way benefited our work. The ideal condition for any institution is a gradually increasing income, so that each year the work of the previous year can be continued, and something new added. During the last twenty years the income of the University has more than doubled, while that of the Observatory has diminished rather than increased. As a result, in the attempt to retain our place among the great observatories of the world, and to fulfil the duties expected of us by other astronomers, our annual expenses exceed our income by several thousand dollars. A large part of this is provided for by the Director, but its entire amount is beyond his means.

By the death of Oliver Clinton Wendell on November 5, 1912, the Observatory lost a careful and painstaking observer. His work with the 15-inch Equatorial, for nearly thirty years, furnished a great number of photometric measurements of a high degree of precision. His enthusiasm for his work continued to the end, his last observation being made within a week of his death.

The rapid development of photographic methods has reduced to a minimum the visual observations made here, while greatly increasing the total output. Thus the only observations of special value made with the East Equatorial, are a few by Professor Bailey of S Ursae Majoris and other objects, in continuation of the work of Professor Wendell. Plans are in progress, however, for giving this instrument a modern and effective mounting with the expectation of using it for photographing by the yellow rays. It will be admirably adapted to this work by its color correction, and will furnish excellent material for studying the visual magnitudes of faint stars. In like manner, the 8-inch Meridian Circle, after forty years of continuous service, is now used only for determining the time. An excellent check is thus furnished of the time sent out by the United States Naval Observatory whose signals distributed by wireless telegraphy have been compared with ours daily during the last four years. The invention of the transit micrometer and other improvements recently made in the meridian circle have rendered the older instruments of little value. Even modern meridian circles should be used only for observations of the bright stars, and under the most favorable conditions. As the original cost of our instrument was only about one twentieth of that of the work done with it, its disuse is not a serious matter. The work of the 12-inch Meridian Photometer, with which more than seven hundred thousand photometric settings have been made by the Director, may now be regarded as completed. It has accordingly been mounted so that it points towards the South Pole, instead of towards the western horizon. The portion of the sky to which it can be turned at any time is thus more than doubled. This is probably the most convenient form of mounting for showing celestial objects to large numbers of visitors, or for measuring the brightness or other properties of objects in the solar system. But for the introduction of photographic methods, this instrument would have a large field of work.

Henry Draper Memorial

The principal work of the Henry Draper Memorial is the Revised Draper Catalogue. Miss Cannon continues to classify five thousand spectra a month, and has now classified 100,155. A little more than half of the sky is covered, so that the total number of stars, excluding duplicates, will probably be somewhat less than two hundred thousand. Many of them are fainter than the ninth magnitude, and some are not in the Bonn or Cape Durchmusterung. Copy for the printer has been prepared for the first hour of right ascension, and contains about five thousand stars. All of the photographs have been taken with the two similar doublets, the 8-inch Draper for the northern and the 8-inch Bache for the southern stars. Nearly all the spectra in the region extending from 0^h to 9^h, and about one third of the northern spectra in the remaining hours of right ascension have now been classified. The number of photographs taken during the year with the 8-inch Draper Telescope is 565, making 38,580 in all. 7,225 stellar photographs were taken here. The total number in the Harvard collection is about 220,000.

Professor King has continued his regular monthly tests of the sensitiveness of the plates. He has also compared his standard light with Hefner and Pentane lamps and has determined the light of the sky by day and by night on the standard scale in use here. Various experiments have been made in bathing plates to vary their color index.

The 11-inch Draper Telescope is in regular use by Professor W. H. Pickering in Jamaica. The excellence of the atmospheric conditions permits valuable observations to be made visually. The principal investigations undertaken were the periodic changes in ellipticity of the disks of Jupiter's four larger satellites, an application of the same method to very close double stars, bright streaks and evidence of present activity in craters of the Moon, and the meteorological and seasonal changes of Mars. An interesting conclusion is that Jupiter's satellites like Saturn's Ring consist of meteors. The changes in shape of the first satellite indicate the existence of two sets of tides. Twenty-seven photographs have been taken with the Cooke Anastigmat, aperture 1.8 inches, mainly on the Milky Way, with exposures of ten and twenty hours. With the latter exposure, as faint stars are photographed as can be seen with the 11-inch Telescope.

In November, 1912, a severe hurricane passed within twenty-five miles, but did not damage the station. The rainfall in three days was 19.7 inches. A simple form of sun-dial has been put in use, and gives the time with an average error of about a second.

BOYDEN DEPARTMENT

The Arequipa Station has continued under the charge of Mr. Leon Campbell. The number of clear nights during the last six months has been somewhat greater than in recent years, but the preceding six months, forming the cloudy season, have been unusually cloudy. The number of photographs taken with the 13-inch Boyden Telescope is 37, making 13,025 in all. The principal work has been the completion for the southern stars of the out-of-focus photographs described in H.A. **59**, Nos. 4, 5, and 6. This will leave the instrument free for a large number of visual observations of southern variable stars. The number of photographs taken with the Bache Telescope is 75, making 44,278 in all. The total number of stellar photographs taken at the station during the year was 2,038. The observations with the pyrheliometer undertaken at the request of the Smithsonian Institution have been continued, 4,186 readings having been taken on 133 days.

BRUCE PHOTOGRAPHIC TELESCOPE

Partly owing to cloudy weather, the work this year with the 24-inch Bruce Telescope has not been satisfactory. 192 photographs have been taken, making 10,806 in all. The principal work has been the attempt to complete the photographs of the Kapteyn Selected Areas. Plans have been made for determining visual and photographic magnitudes of the southern stars, but no results have as yet been obtained.

BLUE HILL METEOROLOGICAL OBSERVATORY

Pending the formal transfer in March, 1913, of the Observatory to Harvard University, all costs of maintenance were defrayed by Mrs. A. Lawrence Rotch. In accordance with the wish of the founder, regular observations have been continued and the record now covers a period of twenty-eight consecutive years. Normals for a twenty-five year period have been prepared and will soon be ready for publication. The usual work of the Observatory was carried on without interruption. Comparative readings at the auxiliary stations, known as the base and valley stations, are now available for a period of nearly twenty-five years. These data will be utilized in studies of best methods of protecting vegetation from injury by frost.

Upper air investigation by means of kites was continued until March, the last flight occurring March 7. This was during a thunder-storm and a discharge of lightning melted a mile of wire and damaged the kite reel. Two of the observers were shocked, one severely, but fortunately no permanent injury resulted. For various reasons the use of *ballons-sondes* or sounding balloons is preferable in exploring the upper air and the kite method is being generally abandoned. Continuance of the kite work is problematical. Blue Hill Observatory was one of the first, if not indeed the first observatory, to fly kites for aerological research. It was also the first to use the sounding balloon, in the United States.

The Observatory is now a part of the Department of Geology but the close affiliation with the Astronomical Observatory which has existed for years will be continued, and every effort made to utilize data for the benefit of the astronomer, particularly in connection with refraction.

In connection with the erection of a memorial fountain not far below the summit, water was piped from Canton. Through the generosity of Mrs. A. Lawrence Rotch and the coöperation of the Metropolitan Park Commission, an ample supply is available for observatory purposes.

The following changes in the observing force have occurred: Mr. C. F. Brooks resigned as research assistant; Mr. L. A. Wells continued as observer-in-chief, and Professor R. DeC. Ward had general supervision until the appointment of Mr. A. G. McAdie as Professor of Meteorology and Director of the Observatory. The last named assumed charge October 1, 1913.

MISCELLANEOUS

Needs of the Astronomical Observatory. — Until the excess of the expenses of the Observatory over its receipts mentioned above has been met, additional expenses cannot be incurred. Other needs are, however, none the less urgent, such as a fireproof building for the library and the growing collection of photographs. There is also a possibility of a great output from a small expenditure by the employment of more assistants to utilize the vast amount of material contained in the Harvard collection of photographs. The gift of Mr. G. R. Agassiz, which continues to provide for two such assistants, illustrates the benefit to be derived from such an expenditure.

Variable Stars. — The organization for the observation of variable stars has greatly increased during the past year. Photographic maps have been prepared of 592 variable stars, and the magnitudes of a sequence of comparison stars for each have been determined on a uniform scale. It thus becomes easy to estimate directly the brightness of these variables. As a result, 14,542 observations have been received, as follows: — Dr. E. Gray, Eldridge, Cal., 1,795; Mr. J. B. Lacchini, Faenza, Italy, 1,441; Mr. H. C. Bancroft, Jr., West Collingswood, N. J., 1,382; Amherst College Observatory, 1,187; Mr. William Tyler Olcott, Norwich, Conn., 1,133; Mr. F. C. Leonard, Chicago, Ill., 913; Mr. A. P. C. Craig, Corona, Cal., 845; Mr. M. W. Jacobs, Jr., Harrisburg, Pa., 811; Mount Holyoke College Observatory, 743; Rev. T. C. H. Bouton, Hudson, N. H., 708; Mr. C. Y. McAteer, Pittsburgh, Pa., 605; Mr. E. L. Forsyth, Needles, Cal., 591; Mr. A. B. Burbeck, North Abington, Mass., 489; Vassar College Observatory, 383; Mr. H. W. Vrooman, Kokomo, Ind., 348; Mr. S. C. Hunter, New Rochelle, N. Y., 332; Miss H. M. Swartz, South Norwalk, Conn., 231; Mr. N. V. Ginori, Florence, Italy, 154; Mr. F. E. Hathorn, Des Moines, Iowa, 149; Mr. O. Mach, Dayton, Ohio, 145; Mr. N. Bruseth, Silvana, Wash., 67; Mr. T. Dunham, Jr., New York, N. Y., 37; Mr. S. H. Huntington, Kerrville, Texas, 37; Mr. E. W. Raymond, South Boston, Mass., 16.

All those sending their observations here early in each month are mentioned in a series of articles sent to *Popular Astronomy*, showing the brightness of each variable. The observations will also be published in the Annals of the Observatory, if they have not been printed elsewhere. In addition to the observations mentioned above, 1,776 were made here, comprising 1,392 by Mr. P. G. O'Reilly, and 384 by Miss I. E. Woods. 512 observations were made at Arequipa, by Mr. L. Campbell. The total number is, therefore, 16,830. The corresponding number for last year was 10,117. The great increase is mainly due to the growth of the American Association of Variable Star Observers, under the careful supervision of Mr. Olcott. The important aims are to secure observations, at short intervals, of the principal variables of long period, and to obtain useful results from large numbers of owners of small telescopes whose work, otherwise, might be of but little value. Both of these conditions seem now to be fulfilled in a highly satisfactory manner.

Observatory of the Rev. J. H. Metcalf. — 269 photographs have been taken by Mr. Metcalf and his assistant, in Winchester, with the 12-inch and 6-inch Telescopes, making the total number with the larger instrument, 1,631. About 150 asteroids have been photographed, and approximate positions obtained and published in the *Astronomische Nachrichten.* Twenty asteroids were discovered, six of which were sufficiently observed to furnish good orbits. They are, 1912 PZ, (736); 1912 QB, (737); 1913 QR, (739); 1913 QS, (740); 1913 QT, (741); 1913 QZ, (747). The last of these has an eccentricity of 20° 9′, exceeded only by four other known asteroids, and thus adding another that approaches the cometary type. Comet B 1913 was discovered by Mr. Metcalf at South Hero, Vermont, September 2, 1913.

The 16-inch Metcalf Telescope has continued in regular use in Cambridge. 1994 photographs have been taken, making the total number 4011. All of the 110 Selected Areas of Kapteyn, north of the Equator, have been photographed and plates have been taken of a large part of them which will permit the photographic magnitudes to be determined on a uniform scale. During July, the correction for color of the instrument was changed by Mr. Metcalf. This has greatly improved the instrument, so that it will now photograph stars a magnitude fainter than before. With an exposure of 10 minutes, stars of the fifteenth magnitude are shown on the best plates. The spectra obtained by it are also greatly improved. A new tail-piece is being constructed and it is expected that curved plates will now be used exclusively. Extensive plans are being made for the determination by it of visual and photographic magnitudes.

Additional Investigations. — Besides the various investigations already mentioned, many others are in progress. One of the most important of these is the determination of standard photographic magnitudes. The International Committee for the preparation of a map of the sky appointed a Sub-Committee on Photographic Magnitudes and the Director of the Harvard Observatory as its Chairman. A sequence of stars has been selected near the North Pole, and for several years Miss Leavitt has been engaged in determining their magnitudes. This work is now completed and is nearly ready for the printer. It will furnish standards as faint as the twentieth magnitude. Forty-nine other regions have been chosen as standards. A sequence has been selected in each and the positions and approximate magnitudes have been found for nearly all.

The measurements by Professor Kapteyn of all the stars in his Selected Areas is now approaching completion. 237,000 stars have been measured. All the northern regions have been photographed here, and nearly all the southern regions at Arequipa. Photographic magnitudes have been found for fifteen standard stars in each of twenty-three of these regions.

Library. — The Library of the Observatory has been increased by 274 volumes and 1,378 pamphlets, making the total number 14,098 volumes and 34,112 pamphlets. It is scattered through the various rooms of the Observatory, and continues in constant danger of destruction by fire.

Telegraphic Announcements. — For many years, the Kiel and Harvard Observatories have served as the centres of distribution of telegrams announcing astronomical discoveries, observations, and orbits, in Europe and America, respectively. A new object discovered in one continent is likely to be observed in the other on the following evening. The entire expense of cabling from Cambridge to Kiel has been borne by the Harvard Observatory. Besides the cost of cable messages, it has been necessary to provide for sending out the telegrams promptly at all times. During the last year thirty-three telegraphic announcements have been made, mainly relating to the discovery and observation of comets. They are sent to all who wish for them, free of expense beyond that charged in each case by the telegraph company. The messages are generally sent by "Night Letter," and can thus be transmitted in ordinary language, instead of in cipher, without increased expense, and generally without serious delay.

Cablegrams intended for this Observatory should be addressed "Observatory, Boston," and all telegrams, "Harvard College Observatory, Cambridge, Mass." All correspondence should be addressed to the Director.

Thirty-two bulletins have been issued, making the total number 532. They are printed promptly and not only contain all the telegraphic announcements but much additional information sent here for that purpose. They are sent without charge to all receiving the telegrams, and, at a price less than cost, to all others desiring them.

Publications. — During the last year Volumes **56**, No. **8**; **64**, No. **8**; **67**; **72**, Nos. **4**, **5**, **6**, and **7**; **74**; **75**, Parts **1** and **2**, have been distributed. Six Volumes, **56**, **64**, **67**, **72**, **74**, and **75**, have thus been completed. **76**, No. **1**, has been completed. The greater portion of **63**, Part **2**, Sequences of Comparison Stars for 279 Variables, and **78**, Part **1**, Variable Stars in Messier 3, are nearly all in type. Also, portions of **69**, Part **2**, Observations with the East Equatorial during the years 1903 to 1912; **71**, No. **3**, Standard North Polar Sequence; **73**, Part **1**, Blue Hill Meteorological Observatory, 1909. The set of Annals from **1** to **70** is therefore completed and distributed with the exception of the second parts of

63 and **69**. Volumes **72**, **74**, and **75** and portions of **71** have also been distributed. Partly owing to extensive printing of the Annals only three Circulars have been issued whose numbers, titles, and dates are as follows: —

177. Maximum Brightness of Algol Variables. March 20, 1913.
178. Stars Having Peculiar Spectra. April 21, 1913.
179. 25 New Variable Stars, principally in Harvard Maps 39 and 45. May 12, 1913.

Various other publications by officers of the Observatory are described in the *Harvard University Gazette*, each month.

EDWARD C. PICKERING, *Director*.